

Lake Tahoe TMDL Forested Upland Source Category Group Load Reduction Analysis

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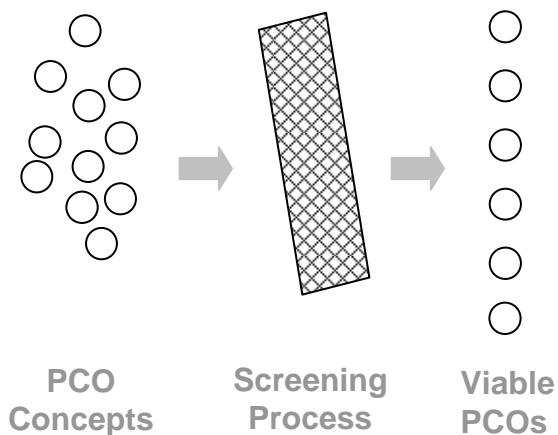
Michael Hogan & Kevin Drake, Integrated Environmental

Introduction to Forested Uplands in the Lake Tahoe Basin

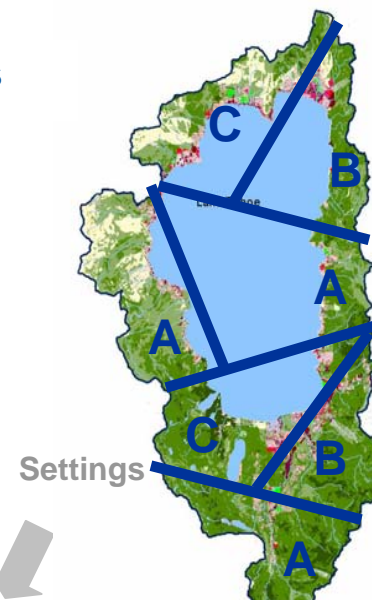
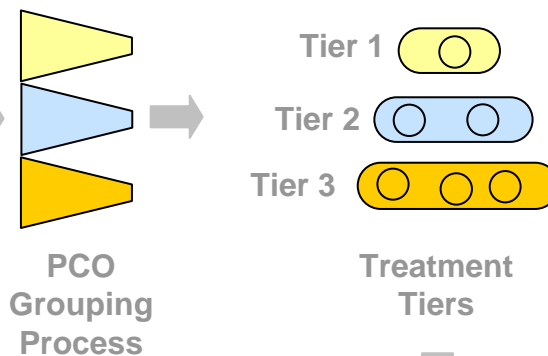
- Represents ~80% of land area in Tahoe Basin
- Diverse array of habitat types, soil types and landscape features
- Many land-uses and activities including ski resorts, unpaved roads, “undisturbed” forest, campgrounds, thinning and fuel reduction activities, hiking, biking, wilderness areas, roadless areas, etc.

Pollutant Reduction Opportunity Development Process

Step 1: PCO Evaluation



Step 2: Site-Scale Analysis



Step 3: Basin-Wide Analysis

Extrapolation Process

- GIS
- Models

Combined Results
Tables

Load
Tables

Sediment
Reduction
Table

Phosphorus
Reduction
Table

Nitrogen
Reduction
Table

Cost
Tables

Total 20 Year
Cost Table

Capital
Cost Table

O & M
Cost Table

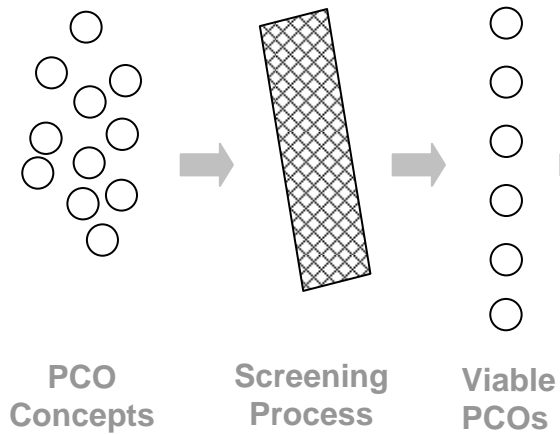
Cost-
Effectiveness
Table

Pollutant Control Options (PCOs)

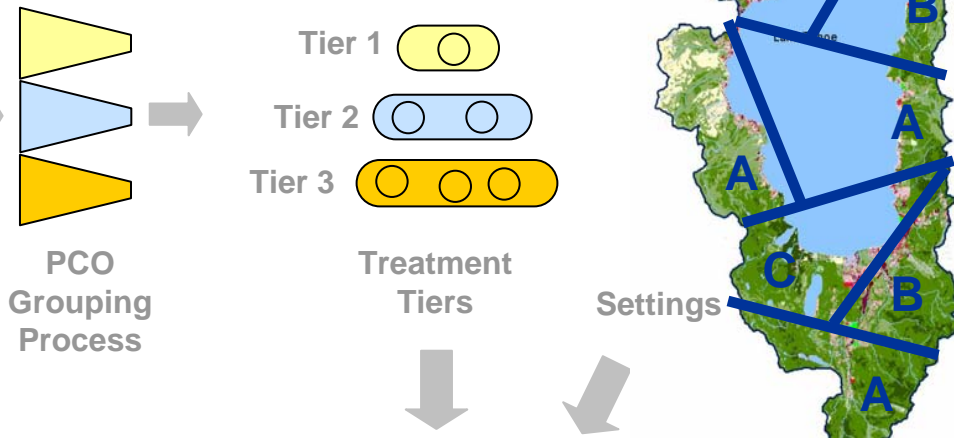
Organic matter amendments	Traffic exclusion
Ripping-subsoiling	Pine needle filter berms
Tilling	Flow path check dams
Soil surface roughening	Hydroseeding
Seeding	Infiltration ditches
Mulching	Infiltration swales
Irrigation	Rock-lined ditches
Functional soil restoration	Settling ponds
Road obliteration	Water bars/rolling dips

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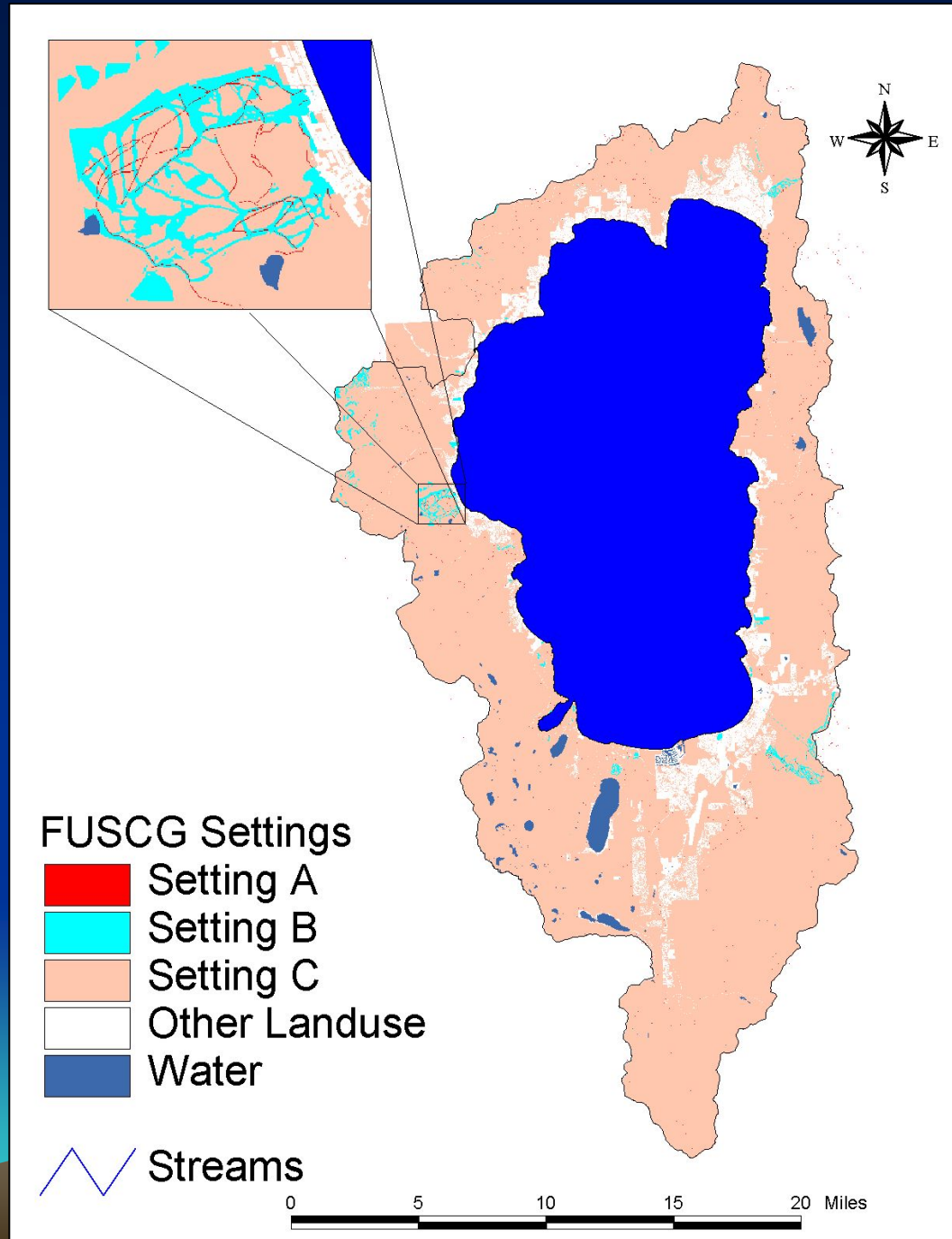
Developing Settings

- Used LSPC model land-use categories as building blocks
- Coordinated with UGSCG to delineate “forested” from “urban” land-uses
- Grouped land-use categories into settings based on functional condition and PCO application

Forested Upland Settings

Setting	Soil Functional Condition	LSPC Land Use Category
A	Bare, highly compacted	Roads_Unpaved
B	Disturbed, surface treatment, no functional mulch cover	Veg_unimpacted EP5
		Ski_Runs-Pervious
		Veg_Recreational
C	Relatively undisturbed, managed forest	Veg_Burned
		Veg_Harvest
		Veg_unimpacted EP4
		Veg_unimpacted EP3
		Veg_unimpacted EP2
		Veg_unimpacted EP1

Total Land Areas of FUSCG Settings



	Area (acres)	% of Forested Uplands
Setting A	311	0.2%
Setting B	1,878	1.1%
Setting C	162,639	98.7%
Total	164,828	

Developing Treatment Tiers

- Tiers represent incremental improvements in soil cover and functional condition
- **Tier 1**—*Standard* treatments used in current practice.
- **Tier 2**—*State-of-the-art* practices designed to achieve *functional* rehabilitation of hydrologic properties.
- **Tier 3**—Treatments designed to develop site conditions that will eventually mimic undisturbed, *natural* conditions.

Setting A Treatment Tiers

Setting	Baseline Functional Condition	LSPC Land-use Category	Treatment Tier 1	Treatment Tier 2	Treatment Tier 3
A	Bare, highly compacted	Roads_Unpaved	Full BMP retrofit (waterbars, rolling dips, armored drainage ditches, stabilize ruts) + annual maintenance	Full BMP retrofit + on-site sediment capture + annual maintenance	Full obliteration/functional restoration (recontouring, soil restoration, seed, functional mulch, block vehicle access)

Setting B Treatment Tiers

Setting	Baseline Functional Condition	LSPC Land-use Category	Treatment Tier 1	Treatment Tier 2	Treatment Tier 3*
B	Disturbed; surface treatment; no functional mulch cover	Veg_unimpacted EP5	Surface treatment (e.g. hydroseeding, straw mulch or erosion control fabric, straw wattles)	Surface treatment with functional mulch cover (pine needles, tub grindings)	Full recontouring, functional restoration (tilling, organic amendments, organic fertilizer, seed, functional mulch cover), establishment of native hydrology and vegetation
		Ski_Runs-Pervious			
		Veg_Recreational			

** Treatment Tier 3 is not achievable for the Veg_unimpacted EP5 land-use category*

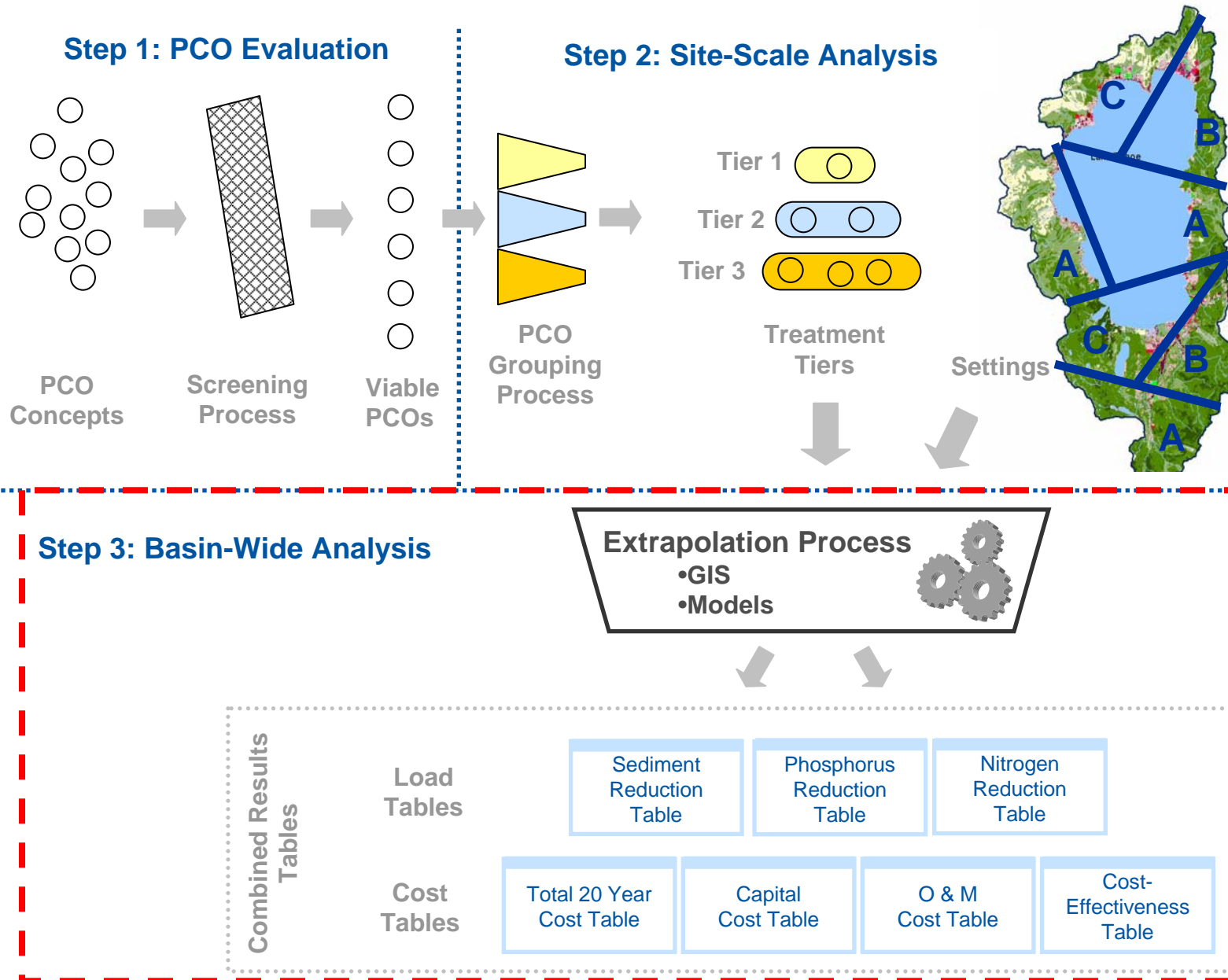
Setting C Treatment Tiers

Setting	Baseline Functional Condition	LSPC Land-use Category	Treatment Tier 1	Treatment Tier 2	Treatment Tier 3
C	Relatively undisturbed, managed forest	Veg_unimpacted EP4	Ground-based equipment + req'd BMPs	Ground-based equipment + full BMPs	Ground-based equipment + full BMPs + restore legacy roads/trails
		Veg_Burned			
		Veg_Harvest			
		Veg_unimpacted EP3			
		Veg_unimpacted EP2			
		Veg_unimpacted EP1			

Required BMPs – waterbar/mulch skid trails, landings and temporary roads; close temporary roads.

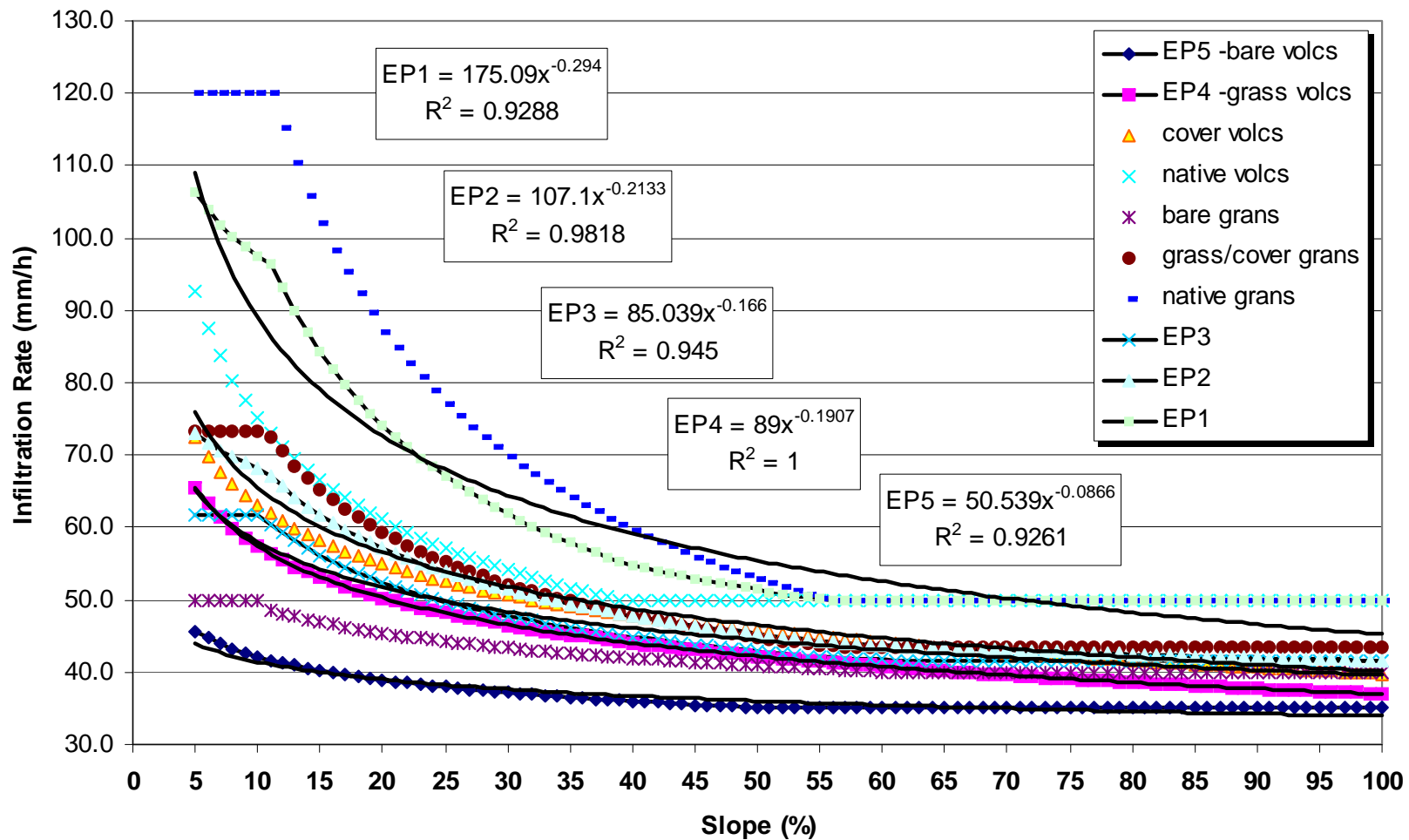
Full BMPs – till, mulch and construct water bars on all skid trails; obliterate/recontour (i.e. full functional restoration) all landings and temporary roads.

Pollutant Reduction Opportunity Development Process



Integrating Field Measurement and Erosion Modeling

Infiltration Rates - All conditions



Functional Condition Classes

Functional Condition Class	Description
A	Fully functional forest soils – limited erodibility, high infiltration rates and sustainable soil nutrient conditions.
B+	Approaching functional soil conditions as per class A; may not yet be sustainable, or are limited by available soils and slope.
B	Functional surface soil protection and initiation towards hydrologic functionality; long-term condition uncertain.
C	Disturbed sites with surface treatment that provide temporary cover but little functional erosion control.
D	No protective surface cover and limited infiltration capacity
F	Compacted bare soil conditions; highly erodible.

Merging Settings, Treatment Tiers and Functional Condition Classes

Setting	Soil Functional Condition	Land Use Category	Base-line	Tier 1	Tier 2	Tier 3
A	Bare, highly compacted	Roads_Unpaved	F	C	B	A
B	Disturbed, surface treatment, no functional mulch cover	Veg_unimpact EP5	D	C	B	B
		Ski_Runs-Pervious	C	C	B	A
		Veg_Recreational	C	C	B	A
C	Relatively undisturbed, managed forest	Veg_Burned	C	C	B	A
		Veg_Harvest	C	C	B	A
		Veg_unimpact EP4	C	C	B	B+
		Veg_unimpact EP3	B	B	B	B+
		Veg_unimpact EP2	B+	B+	A	A
		Veg_unimpact EP1	A	A	A	A

Basin-wide Loading Analysis Process

1. Get LSPC model data for all 184 sub-watersheds. *Assume basic hydrologic processes are in effect*
2. Determine baseline loading for each sub-watershed from FUSCG regression equations.
3. Estimate and optimize scaling factor for each sub-watershed such that predicted sub-WS sediment loading is equivalent to that from LSPC.
4. Calculate loading for each setting – treatment tier combination based on soil functional condition classes and corresponding regression equations.
5. Sum loading for each setting across each sub-watershed then sum results from each sub-watershed across the Basin.

Basin-wide Cost Analysis Process

- Obtain cost information from field practitioners, Basin agencies, forestry contractors, ski resort operations managers and FUSCG's contracting experience.
- Assume full treatment costs best reflected by private contractor rates
- Estimate functional life expectancy of each treatment based on observed and measured performance in the field, local agency estimates, FUSCG experience and best professional judgment.
- Estimate costs for each setting-treatment tier combo then sum for the total area (acres) of each setting across Basin to derive Basin-wide total cost and cost per acre estimates.

Basin-wide Load Reduction Matrix

Setting A – Unpaved Roads – 310.8 acres

	LSPC/Base	Tier 1	Tier 2	Tier 3
Sediment (MT/yr)	353.56	313.09	344.65	349.05
Silt (MT/yr)	124.51	113.60	122.55	123.59
Clay (MT/yr)	2.15	2.03	2.14	2.15
TN (MT/yr)	0.47	0.127	0.141	0.222
TP (MT/yr)	0.614	0.157	0.187	0.261
Surface Flow (m³/yr)	142,079	38,535	42,812	67,570

Basin-wide Load Reduction Matrix

Setting B – Ski Runs, Recreation Areas – 1877.9 acres

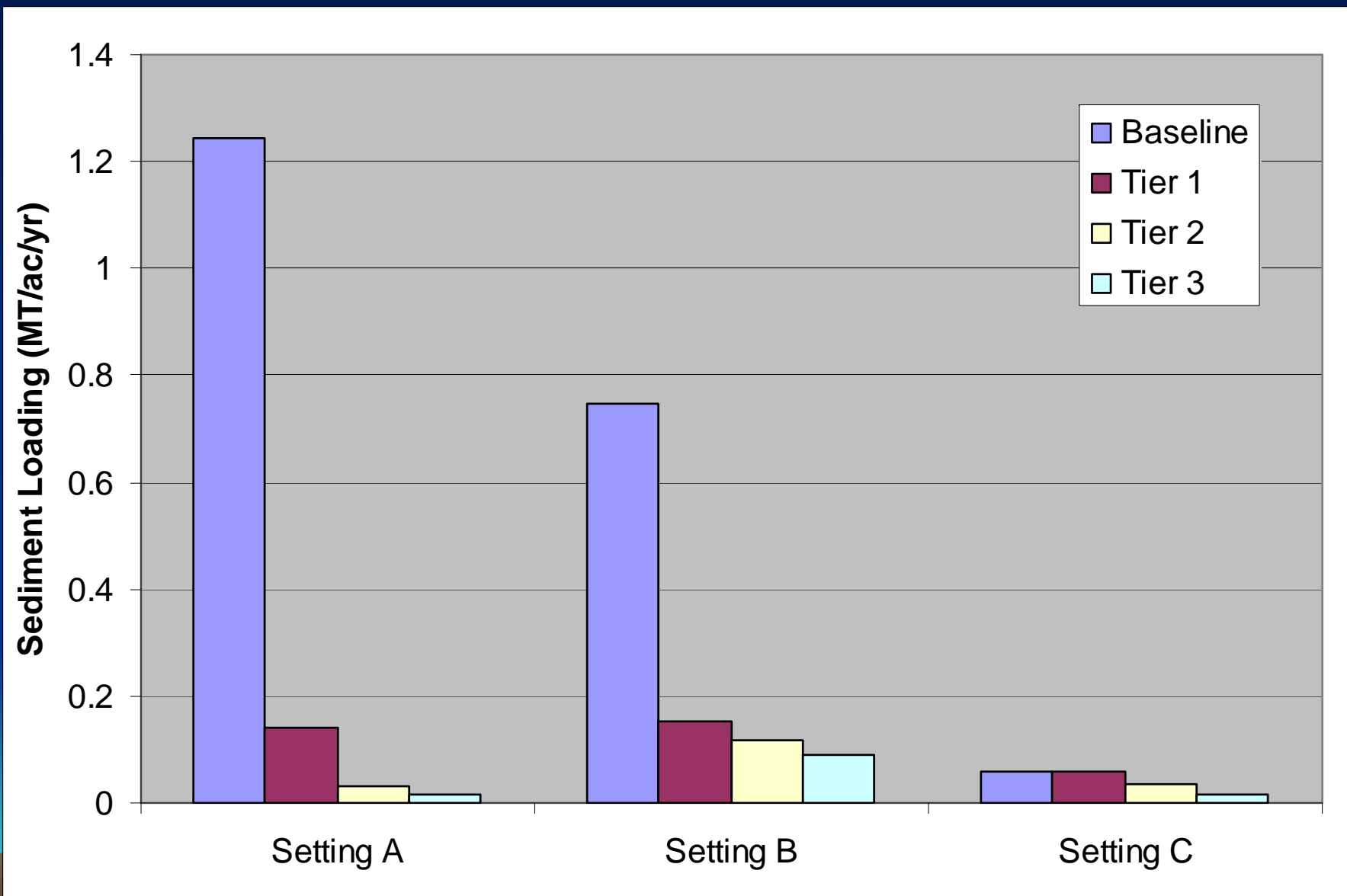
	LSPC/Base	Tier 1	Tier 2	Tier 3
Sediment (MT/yr)	1422.69	1129.50	1197.11	1249.37
Silt (MT/yr)	524.72	421.99	461.49	475.23
Clay (MT/yr)	7.93	6.55	7.33	7.44
TN (MT/yr)	0.633	0.025	0.04	0.162
TP (MT/yr)	0.542	0.021	0.043	0.125
Surface Flow (m³/yr)	1,137,257	45,136	99,180	262,086

Basin-wide Load Reduction Matrix

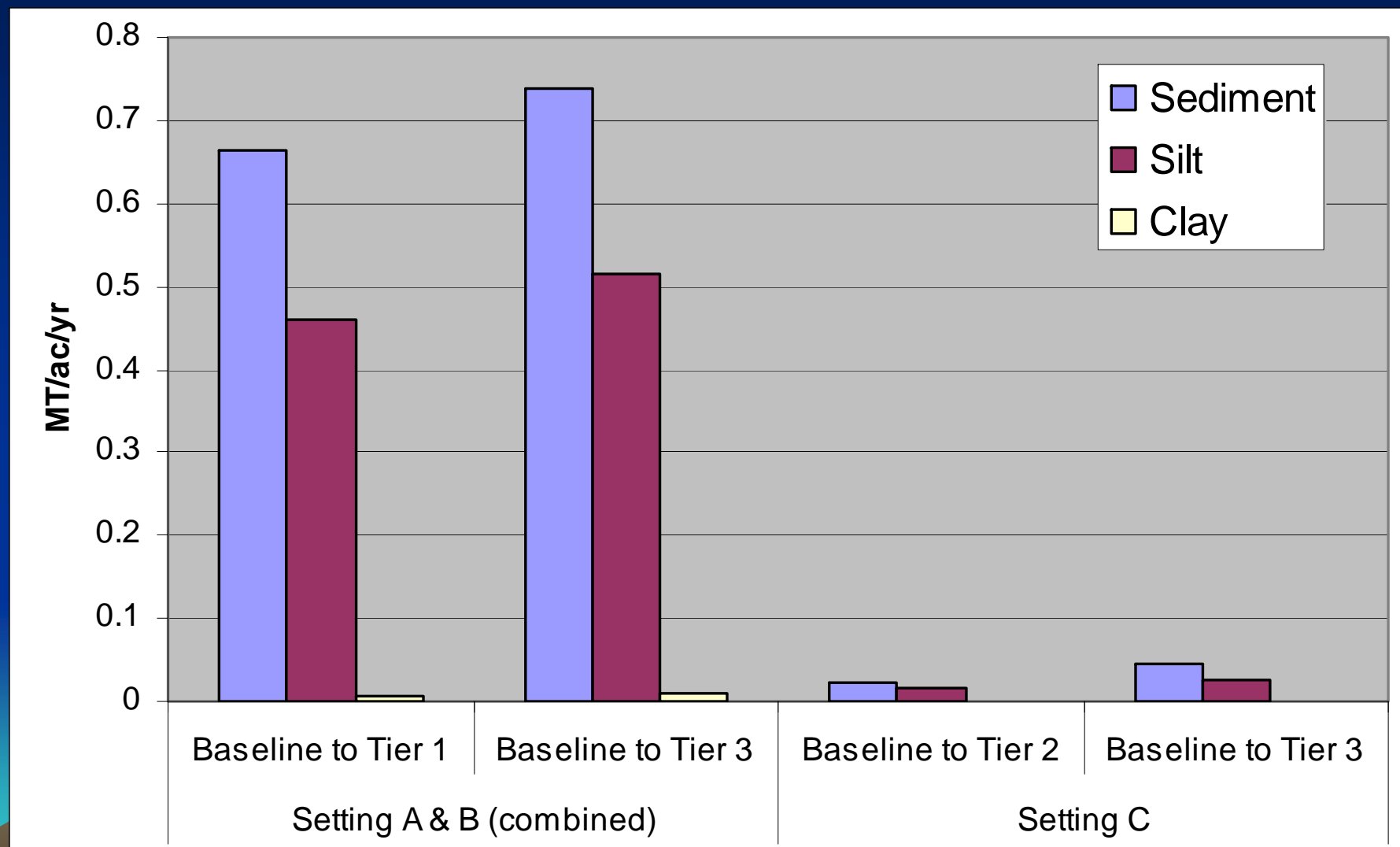
Setting C – Forested Areas – 162,639 acres

	LSPC/Base	Tier 1	Tier 2	Tier 3
Sediment (MT/yr)	9579.28	0	3600.35	7325.55
Silt (MT/yr)	3840.56	0	1719.94	3141.43
Clay (MT/yr)	44.10	0	24.31	38.89
TN (MT/yr)	9.538	0	0.049	1.492
TP (MT/yr)	2.383	0	0.027	0.329
Surface Flow (m³/yr)	43,205,109	0	202,577	6,969,652

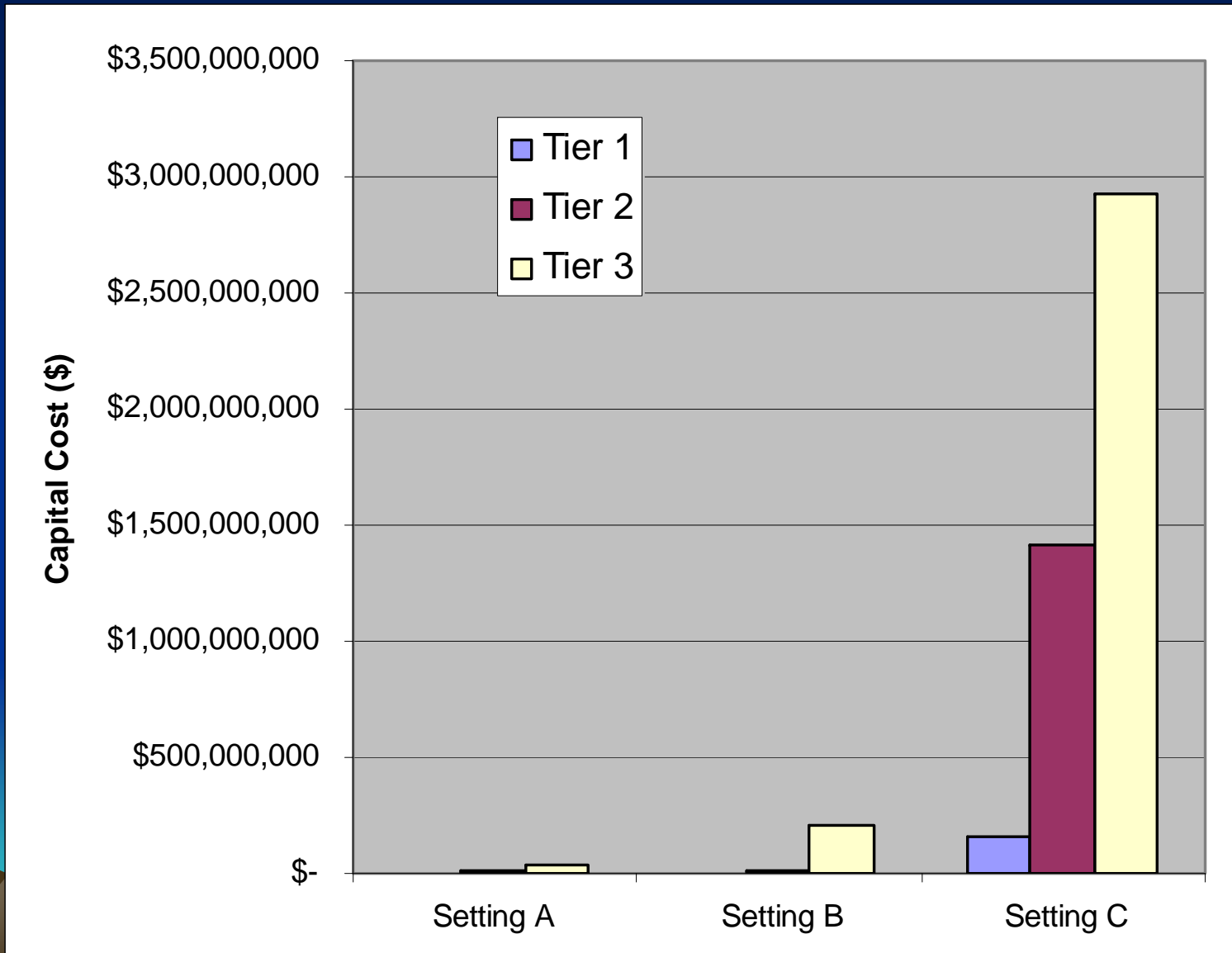
Basin-wide Annual Sediment Loading Per Acre



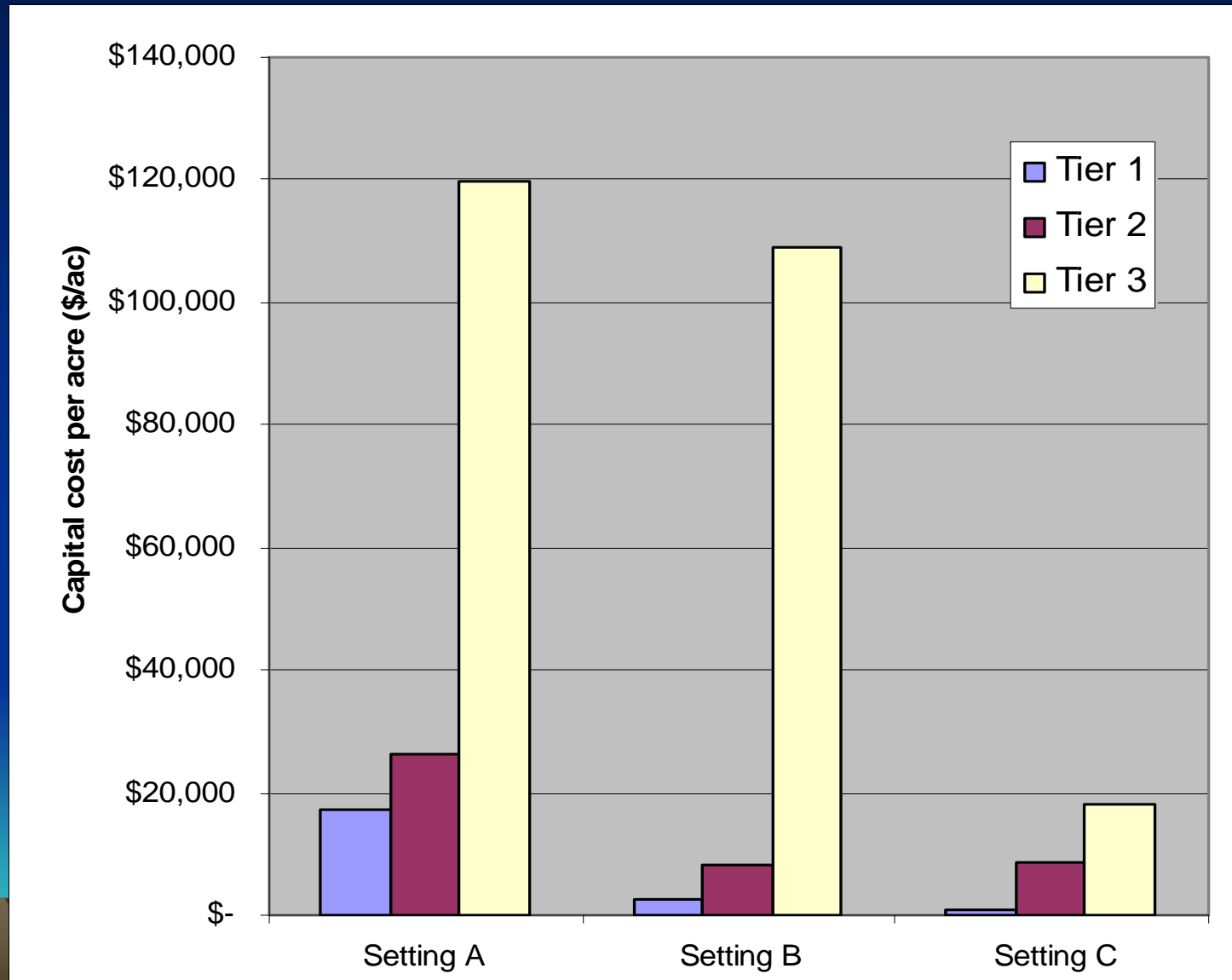
Change in Annual Loading Reduction Per Acre for Different Treatment Tiers



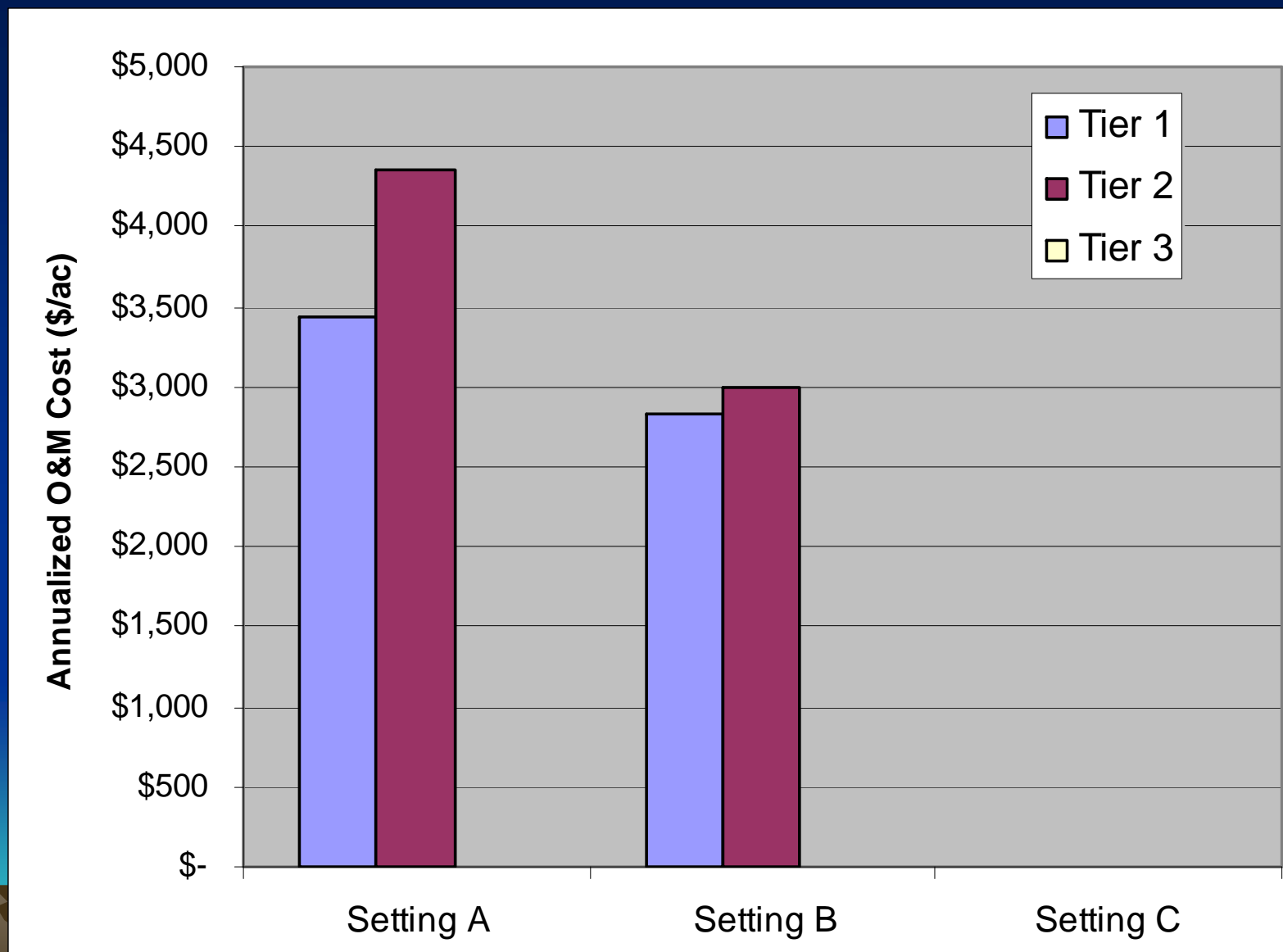
Capital Cost Estimates



Capital Cost Per Acre Estimates



Annualized O&M Cost Per Acre Estimates



Key Findings

- Greatest load reductions per acre are associated with disturbed volcanic soils on the north and west sides of the Basin, such as unpaved roads, recreational and ski run areas (Settings A and B).
- Per acre load reductions from forested areas are an order of magnitude smaller than per acre reductions from unpaved roads, ski slopes and campgrounds.
- Annual per acre fine sediment loading rates from unpaved roads are roughly double that from ski trails and 20–40 times greater than loading rates from undeveloped forested areas.
- In forested areas, obliteration of legacy areas has the greatest potential to efficiently reduce loading, especially if conducted in combination with planned thinning and fuels reduction treatments.